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RESEARCH DEPARTMENT

Some Measurements on an E.M.I. Microwave Link Type ML6B with Particular Reference to the B.B.C. Version of the N.T.S.C. Colour Television Signal

Report No. T-055

(1955/10)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

The report describes a series of measurements carried out on a frequency-modulated television link, particular attention being paid to those characteristics which are of prime importance when the link is used with a colour signal of the N.T.S.C. type.

1. INTRODUCTION.

The N.T.S.C. type[1] of colour television video signal contains two principal components. The first, similar in form to a normal black and white video signal, represents the instantaneous brightness of the scanned image and is referred to as the luminance signal. The second or chrominance signal component consists of a suppressed-carrier modulated wave whose phase relationship to a standard reference signal, referred to as the "burst signal", is indicative of hue and whose amplitude, relative to the associated luminance signal, represents the degree of colour saturation. The suppressed carrier of the chrominance signal is called the "sub-carrier".

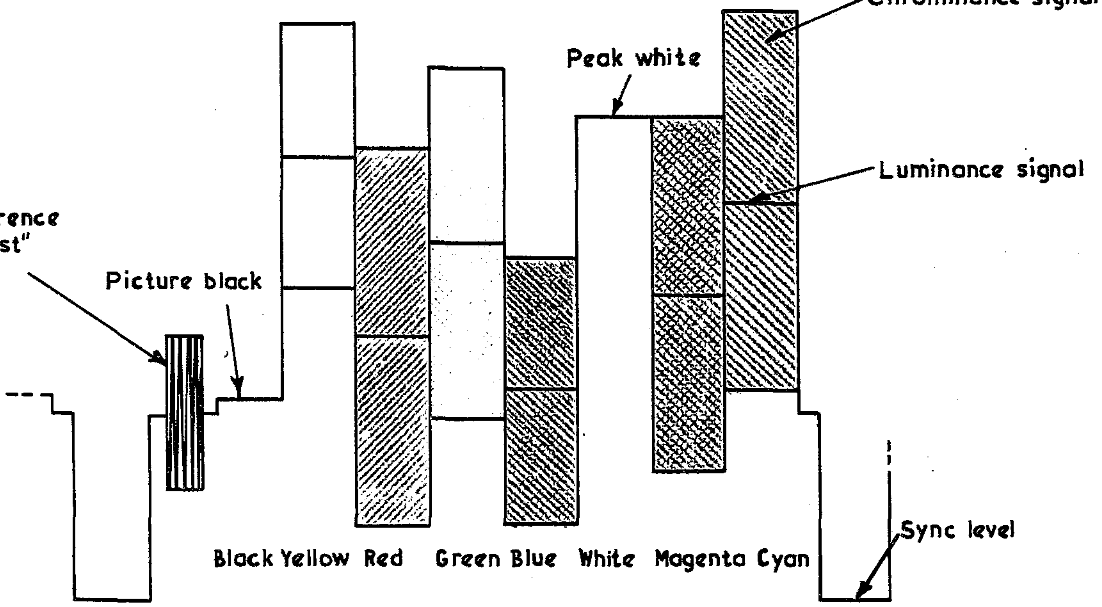

Fig. 1 - The line waveform of a signal containing saturated colours

Fig. 1 shows the composite signal waveform representing one line of a colour picture containing the saturated additive and subtractive primaries together with black and white. The diagram also shows the synchronising and colour reference "burst" signals. As will be seen, the position in the signal magnitude range of the chrominance wave "zeros" is determined by the corresponding luminance signal value. It will be apparent that a video transmission circuit must introduce no distortion of such a form that variations of luminance signal value result in chrominance signal phase shift.

In the presence of such distortion, sometimes referred to as "differential phase" distortion[2], the phase of the chrominance signal, after transmission, will be in error by an amount depending upon the associated luminance signal value. The colour reference "burst" is positioned about signal black level and can, therefore, only be affected by changes of luminance signal when the composite signal is passed through a circuit attenuating the d.c. component. The presence of "differential phase" distortion must, therefore, result in errors of reproduced hue; saturated colours of high luminance (yellow, green and cyan) being, in general, particularly affected by this distortion. In a video transmission circuit involving the frequency modulation and demodulation of a carrier wave, the instantaneous video signal value is represented by a deviation of the carrier frequency. It is essential, therefore, that the carrier frequency (rf and if) circuits should have a very constant delay for that frequency range occupied by the modulated signal spectrum if no "differential phase" distortion is to result.

The purpose of this report is to describe a series of closed circuit tests carried out on a microwave television link employing frequency modulation. These tests, in general, have been designed to examine some of the transfer characteristics of the link and, in particular, to test for the presence of "differential phase" distortion. No effects due to propagation of the signals through space were explored because the two reflectors of the microwave link transmitter and receiver were placed back to back in the laboratory.

2. GENERAL.

Four forms of test have been carried out. These are:

a. response to a transient excitation or the output response of the link to an input time function closely approximating to the sin $\omega t/\omega t$ form,

b. measurements of the steady-state amplitude-versus-frequency and phase-versus-frequency responses,

c. differential phase or measurements of any phase changes in a sub-carrier output wave of fixed amplitude and frequency when added to a luminance signal which is itself variable in discrete steps,

d. subjective assessment, using a colour picture monitor, of any changes in hue when an N.T.S.C.-type colour signal, conforming to B.B.C. standards, is passed either directly to the colour decoding equipment or via the microwave link.

Tests a and b are intended to examine the link performance in terms of a low-pass linear network analogue. The remaining tests are those referring directly to "differential phase" distortion.

3. METHODS OF TEST AND RESULTS.

For all the tests carried out both the input and output terminals of the link were available in the laboratory, the aerials being disposed back to back and therefore radiating in opposite directions in such a manner that the receiver input level was typical of normal operation. The input and output signals were of the standard amplitude of 1 V d.a.p. and except where stated otherwise the carrier frequency deviation of the link was maintained at the normal value.

3.1. The Pulse Test.

The test pulse, of sin $\omega t/\omega t$ shape, was produced by accurately limiting the spectrum of an extremely narrow pulse to the range 0–3 Mc/s. This function was performed by means of a phase-corrected low-pass filter. The test pulse, forming the input to the link, was displayed by a waveform monitor. A photographic reproduction of the display is shown in Fig. 2. Fig. 3 shows a similar reproduction of the pulse observed at the output of the link.

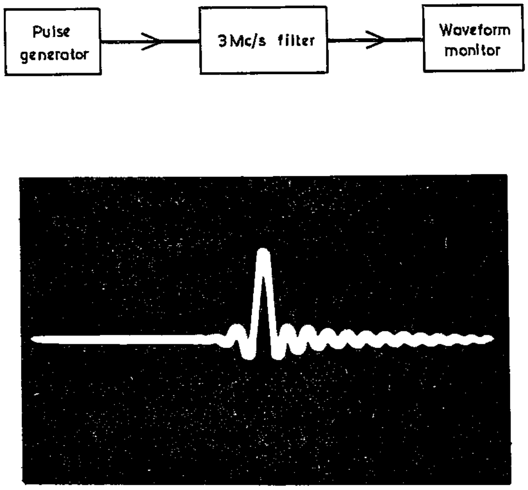

Fig. 2 - The test pulse

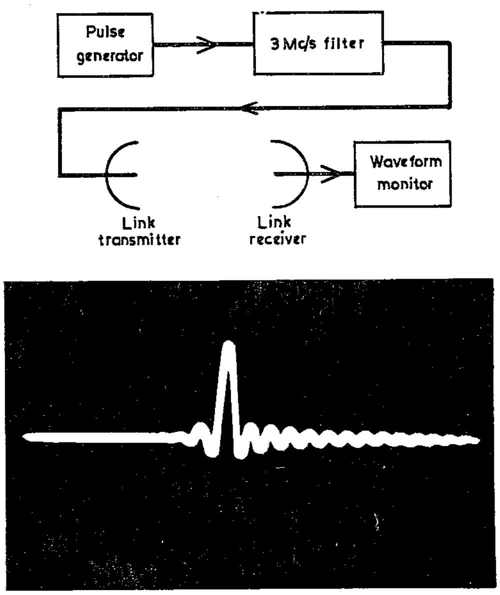

Fig. 3 - Response of the link to the test pulse

A comparison of the two waveforms leads to a conclusion that the link possesses a satisfactory transient response if the spectrum of the signal is limited to 3 Mc/s.

3.2. Steady-state Tests Carried Out on the Link.

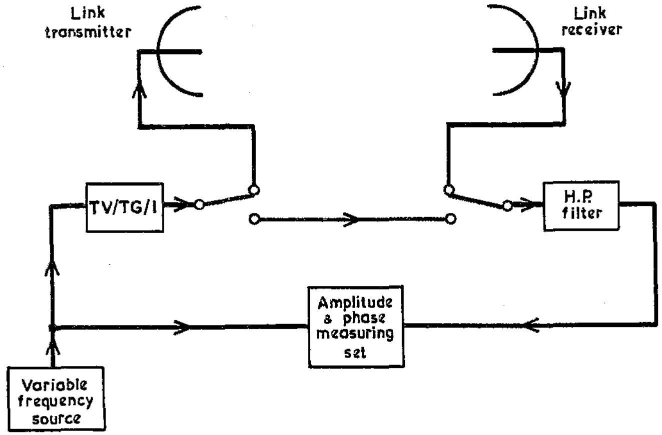

Fig. 4 - Apparatus used in steady-state measurements

These tests were effected by means of an amplitude and phase measuring set wherein accurate comparisons of amplitude and phase angle were made between sinusoidal signals appearing at the input and output of the circuit under test.

Fig. 4 shows the arrangement of the apparatus.

In order to simulate normal working conditions a television test signal generator (TV/TG/1) was used to produce a composite waveform containing line synchronising and suppression pulses together with a simulated picture-signal consisting of a variable frequency sine-wave added to a variable d.c. component or "lift". Fig. 5 shows the composite waveform for two values of "lift" to synch. ratio.

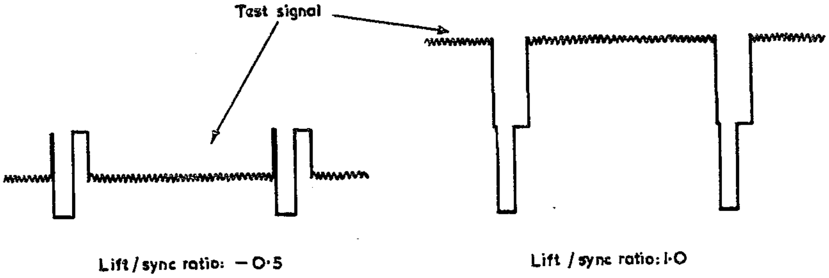

Fig. 5 - The composite test signal used in steady-state measurements

As will be seen from Fig. 4 the composite waveform was fed, either directly or via the link, to one of the input connections of the amplitude and phase measuring set. In order that the latter equipment should operate satisfactorily it was found necessary to insert a high-pass filter into the circuit, having a cut-off frequency of 150 kc/s, in order to remove the d.c. component of the signal and the majority of the energy contained in the synchronising and suppression pulses.

The reference signal used for comparison in the amplitude and phase measuring set was obtained directly from the variable frequency source.

3.2.1. The amplitude/frequency and phase/frequency characteristics.

These characteristics were measured for the range of frequencies 600 kc/s to 3·3 Mc/s using a small sine-wave test signal superimposed upon a d.c. component corresponding to the peak-white level.

Fig. 6 shows the amplitude/frequency response obtained for the link.

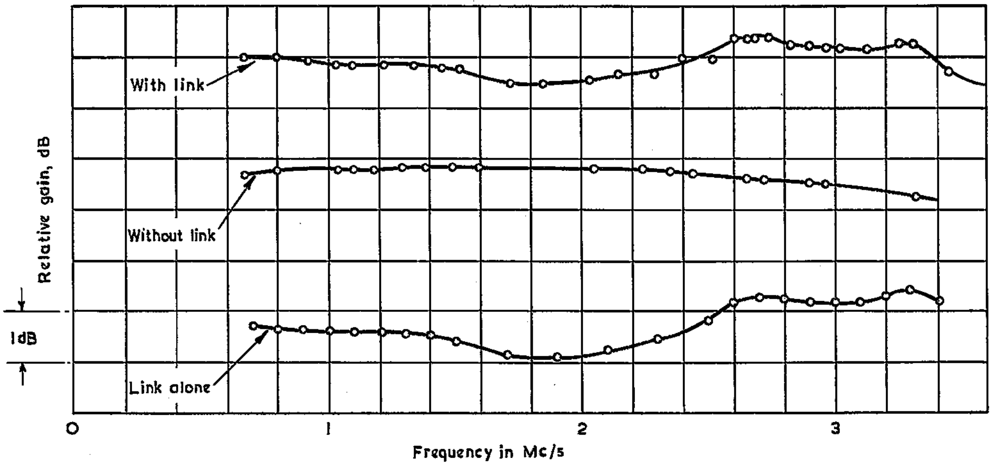

Fig. 6 - Relative gain versus frequency characteristic

In order to achieve an accuracy of ± 2° in measurements of phase-angle as a function of frequency, it was found necessary to choose test frequencies coinciding with minima in the residual spectrum of the synchronising and suppression pulses and these frequencies were measured, by means of a wavemeter, to an accuracy of ± 1 kc/s.

After measuring the phase-angle/frequency characteristics of the test circuit both without and with the link included, a constant arbitrary phase-angle together with a suitable constant group delay were subtracted from each set of results. From the difference between these curves the frequency dependent phase error and group delay characteristics of the link were calculated. These results are shown in Fig. 7.

3.2.2. The "differential phase" characteristic.

In order to measure any chrominance signal phase distortion which might occur for different luminance levels in an N.T.S.C. type of composite colour signal, the phase-shift of a 2·66 Mc/s sine-wave was measured for different values of added d.c. component in the test waveform. This d.c. component was varied from a negative value (below black level) to a positive value corresponding to the peak-white level.

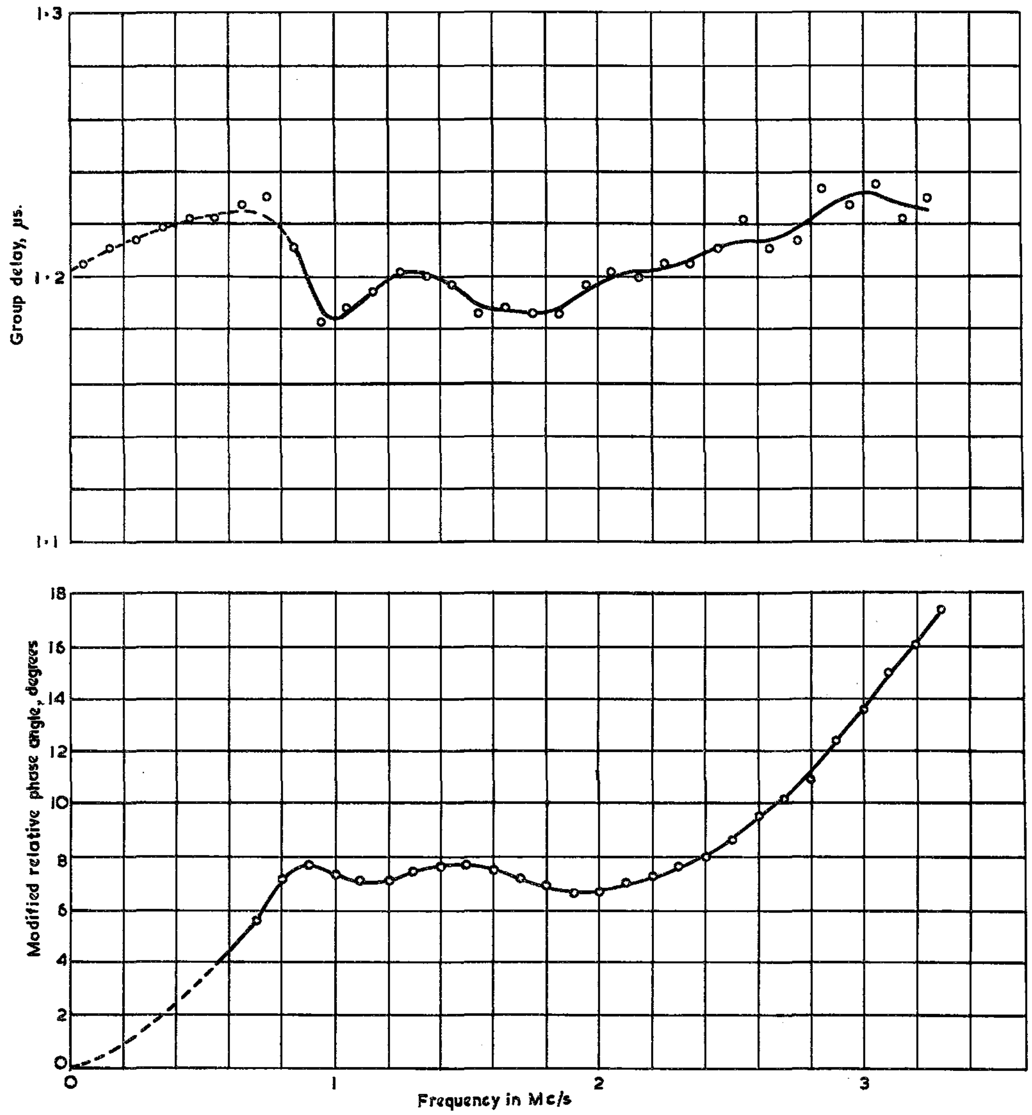

Fig. 7 - Group delay and frequency-dependent phase-error characteristics of microwave link

——————— Measured characteristics

- - - - - - - Assumed characteristics

The total excursion of the test sine-wave was arranged to occupy 5% of the total video range (black level to peak white). As the peak value of the composite signal may exceed peak white, the test was carried out with a peak carrier deviation of 5 Mc/s (the normal peak-white deviation being 3·3 Mc/s). As before, measurements were made without and with the link included in the circuit under test and Fig. 8 shows the "differential phase" distortion obtained for various values of the added d.c. component (shown as "lift"/sync amplitude ratio).

3.3. Tests with a Composite Colour Signal.

Fig. 9 shows the arrangements for these tests. By means of the switch S the composite colour signal connection between the encoder and decoder could be made either directly (switch position X) or by the link under test (position Y).

As the composite signal used in the tests did not contain a colour reference "burst", the decoding synchronous demodulators were driven by a continuous sub-carrier signal obtained either directly from the encoding equipment or through a calibrated phase shifter.

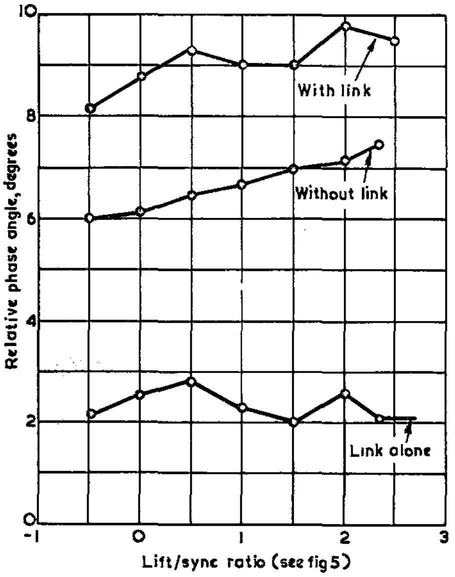

Fig. 8 - Phase/lift characteristic at constant frequency f = 2·659 Mc/s

The test procedure consisted of comparing the pictures obtained on the colour monitor screen for the two positions X and Y of the switch S. Matching of the pictures thus obtained was achieved by adjustment of the calibrated phase shifter when the switch S was in position Y. The above procedure was repeated separately for a scene containing various colours of high saturation and for six completely plain pictures consisting of the saturated colours red, green, blue, yellow, magenta and cyan, each having maximum luminance. It was found that in all seven tests the same phase shifter setting was required.

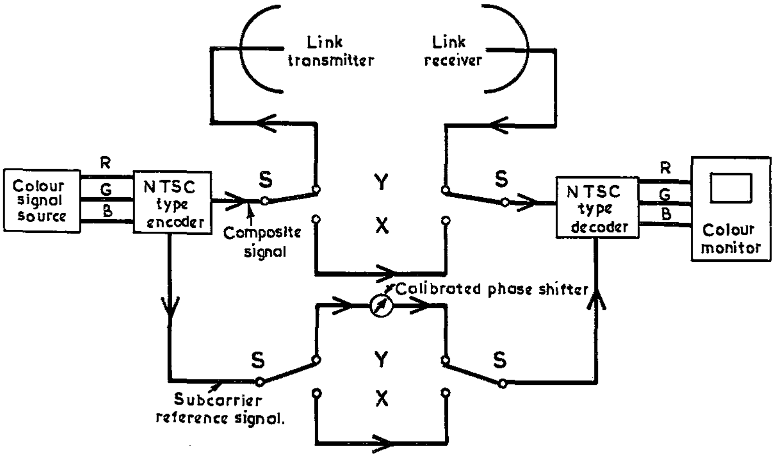

Fig. 9 - The arrangement of apparatus for the colour-picture tests

These tests indicate that the link does not suffer from any differential phase distortion observable by subjective measurement techniques.

4. CONCLUSIONS.

From the results obtained, it would appear that the microwave link, ML6B, is suitable for use with the N.T.S.C. type of colour television signal as modified to conform to B.B.C. standards.

The group delay and "differential phase" characteristics are such that several of such units may be used in tandem without undue distortion resulting.

5. ACKNOWLEDGEMENT.

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6. REFERENCES.

1. Petition of the National Television System Committee for Adoption of Transmission Standards for Color Television. July 1953.
2. T.M. Gluyas, "Television Transmitter Characteristics in Color Broadcasting". R.C.A. Rev., Vol. XV, No. 3. September 1954.